MONTHLY WEATHER REVIEW

ALFRED J. HENRY, Editor.

VOL. 49, No. 6. JUNE, 1921. CLOSED AUG. 3, 1921
W. B. No. 743. ISSUED AUG. 31, 1921

KONA STORMS.

By LAWRENCE H. DAINGERFIELD, Meteorologist.

[Weather Bureau, Honolulu, Hawaii, Apr. 23, 1921.]

SYNOPSIS.

"Kona," or southerly, winds over Hawaii are believed to be local phases of reversed or disturbed pressure distribution over the north Pacific. Five principles are stated in support of this theory. A review of the December 22–28, 1920, kona storm is given, in demonstration of the theory, supported by several maps. A list of kona storms from 1914 to date is given in tabular form.

The word "kona" is of Polynesian origin, meaning "leeward." The Hawaiians of antiquity had no words to indicate the points of the compass. When asked the direction to a certain place, they would say "mauka" or "makai"—meaning "mountainward" or "toward the sea." Possibly they would use the well-known local geographical expressions of "Ewa" or "Waikiki," meaning in the direction of those two suburbs of Honolulu.

In like manner the kona storm received its name, meaning in its simplest form that the leeward sides of the several islands of Hawaii had become temporarily the windward sides. The northeast or trade wind is dominant throughout the Territory. Consequently, the term "kona" applies to southerly or southwesterly winds.

The literature on kona storms is extremely meager, despite the fact that these peculiarly Hawaiian storms are of relatively frequent occurrence and were early recognized as prominent phenomena and of vital importance to the drier sections of the several islands. It is a well-established fact that many broad areas of Hawaii, in the drought-stricken shadows of the sheltering hills and mountains, acting as barriers to the trades, would be nothing but desert wastes, except for the somewhat fortuitous coming of the kona storms.

These storms are not unmixed blessings, however. Trees, crops, agricultural lands, homes, and whole villages, have been washed away at times, with resultant life and property loss. Forests have been flattened by the attendant winds and leeward harbors and coast lines rendered dangerous to shipping on the sea. Counting both profit and loss, however, it has been found that the balance is largely advantageous to the communities visited by these storms.

In view of the preliminary remarks, it may seem presumptuous on the part of the writer to attempt a solution of the kona-storm riddle, placing it on the way to a scientific solution. Nevertheless, we attempted a presentation of our first study of konas before the Pan-Pacific Scientific Conference, held in Honolulu last August. The accumulation of observed facts since the preparation of the paper of last August has tended to substantiate the views then expressed relative to the cause of konas.

The phenomenon of kona storms appears to rest on the following five basic meteorological facts:

1. The Hawaiian Islands lie just south and southwest of the great north Pacific high-pressure area. The center of this high-pressure area reaches its farthest north and west position, slightly to the north of the 40th parallel and near 150°, west longitude, during July, August, and September. The central region of high pressure, however, is between 30° and 40°, north latitude, and to the east of the 140th meridian during the colder months—from November to February, especially.

2. The high-pressure area is most enduring and reaches its maximum strength during the warm months, with August as its peak month, at the time of its most northern and western position. This fact is in complete harmony with another well-known fact, namely: That land masses acquire and lose heat much more rapidly than do the vast oceanic areas. The continent of North America is consequently under low-pressure dominance in summer, while a considerably higher pressure prevails over the cooler north Pacific.

3. Inasmuch as the direction and force of wind depend upon the relative position of high and low pressure areas, and the steepness of the intervening pressure gradient, we find the time of the most persistent trade winds to be during the warm months of the year. The earth's rotation causes the trades to assume a more nearly east-west course as the equatorial low-pressure belt is approached.

4. Conversely, we find the colder months, when the north Pacific high area is weakest and drawn closest to the United States coast, that the trades are most fickle. There are occasions, indeed, when they are suppressed over Hawaii and counter, or southerly, winds spring up, indicating that a reversal in trend of the pressure gradient has occurred.

5. We must introduce at this time another pressure system to explain the reversal in wind direction, noted immediately above. To the north and northwest of the north Pacific high area lies the Aleutian low-pressure area. This is a well-defined and practically permanent depression which occupies the vicinity of the Aleutian Islands during the colder months of the year; the depression disappears during the summer season.

Let us see how these facts apply to these peculiarly Hawaiian storms. Recalling that the Aleutian Islands low area reaches its greatest depth during the colder season, or months of most frequent kona storms; that this is the time when the north Pacific high area dissipates to

a marked extent and shrinks eastward toward the California coast; we observe that the high-pressure belt lying to the north of Hawaii during the late autumn, winter, and early spring months occasionally breaks down completely. At such times the gradient, ordinarily for northeast winds, is reversed and southeast, shifting to south and southwest, winds set in over the islands beginning at the extreme northwest portion of the chain and progressing southeastward. The force of the southerly winds and their duration is of course dependent upon the magnitude and position of the barometric depression. It seems probable that the latter extends southwestward from the Aleutian LOW in the form of a trough or V-shaped depression. Frequently three or four days are required for these southerly winds to swing across the eight larger islands of Kauai, Niihau, Oahu, Molokai, Lanai, Kahoolowe, Maui, and Hawaii, attended by moderate to heavy precipitation.

These migrating, wet, southerly winds are the typical konas of Hawaii—merely local phases of vast barometric depressions. Thus, the ordinarily dry, leeward slopes become temporarily the windward slopes and are deluged with water. The more directly these southerly winds strike the steep slopes of the hills and mountains, known locally as "palis," the quicker and freer the condensation and the more torrential the precipitation.

The most pronounced kona storm experienced in Hawaii since the inauguration of forecasting, about one year ago, occurred during the period of December 22–27, 1920. For example, on Oahu with 37 rainfall reporting stations the amount and distribution of rain December 21 to 26 may be seen from the small table below:

Dates.	Number of rain reports.	Average amount (inches).	Dates.	Number of rain reports.	Average amount (inches).
Dec. 21	13	0.22	Dec. 24	37	4.15
Dec. 22	14	.91	Dec. 25	32	.98
Dec. 23	36	3.12	Dec. 26	26	.03

The first hint of this storm came from Midway Island, p. m., December 20, when the pressure had fallen to 29.84 inches. By the evening of the 22d, the pressure at Midway had fallen to 29.36 inches, with the wind veering to the west and reaching a maximum velocity of 38 miles from the west. The pressure rose slowly to 29.46 by the evening of the 23d, on which date the wind velocity reached a maximum of 72 miles from the northwest—a record for the station. Thereafter the pressure rose slowly at Midway, although oscillating somewhat, until normal pressure was again reached on the 28th. Westerly winds prevailed throughout the time of rising barometer at Midway. Upon the arrival of the Commercial Pacific Cable Co. schooner *Flaurence Ward* from Midway Island, Capt. George H. Piltz, of that ship, supplied us with valuable meteorological data. A copy of *Flaurence Ward* weather log, December 21 to 25, 1920, appears in table No. 2 below.

It appears that when the ship was in north latitude 27° 40′ and west longitude 167° 30′ at 1:30 a. m., 157° 30′, meridian or Honolulu time, December 22, her barometer read 29.75 and the wind was from the east-northeast, with force 5. Thereafter the pressure fell rapidly, with a veering wind through the east, southeast, south, to southwest during the next three days. The lowest pressure reached was 29.10 inches at midnight, December 23–24, in latitude 27° 40′ north and longitude 166° 15′ west, at which time the wind was in the south-southwest, and reaching a force of 11 shortly thereafter. Terrific lightning and heavy rain were experienced during the evening of the 22d, and squalls and lightning from 4 a. m. of the 23d to noon of the 24th. The quick veering of the wind from southeast to south-southwest, during the 22d, indicates that the region of low pressure was extremely narrow and that the schooner was relatively near the southern tip of a V-shaped depression.

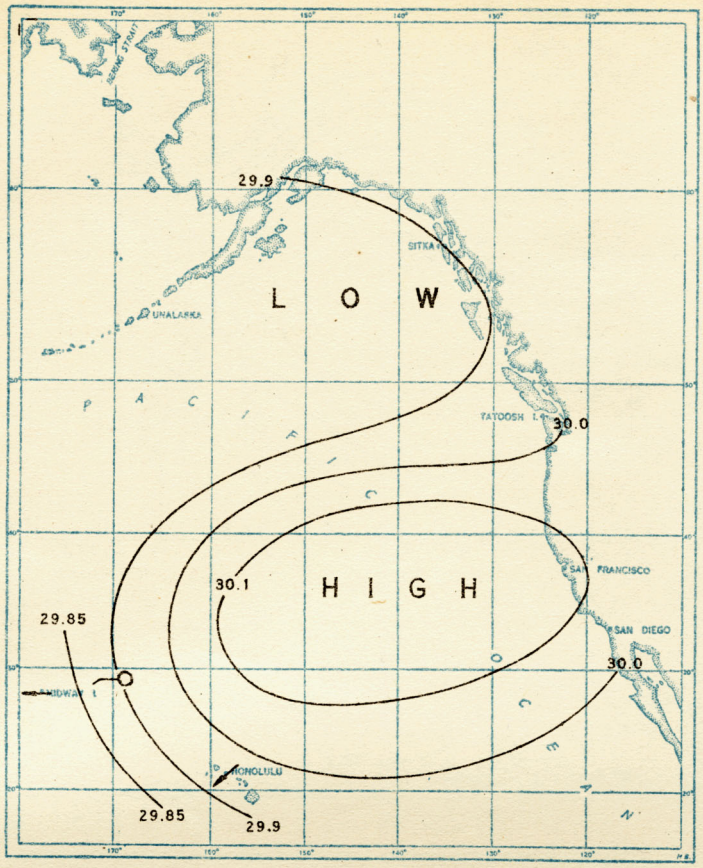
At Honolulu, the wind veered from northeast to east between 6 and 7 a. m.; to southeast, between 8 and 9 a. m., and to south, between 5 and 6 p. m., December 22d. Rain began at 7:55 p. m. of 22d, continuing with slight intermissions until 6:15 a. m., 25th; the heaviest fall was on the 23d, and the lowest pressure, 29.73 inches, was reached at 3:10 p. m. of the 24th. The wind veered into the southwest during the evening of the 24th and into the west between 5 and 6 a. m., of the 25th, after which time the rain ceased and the weather improved and the kona was practically over, although cloudy throughout the day. The maximum velocity of the wind was 36 miles from the west at 5:18 a. m., December 25. By the evening of the 25th, the wind had veered into the northeast quadrant and the pressure was approaching normal.

Judging by the time of the beginning and ending of the general rain over the several islands, we find that the kona storm under consideration began over Kauai early on the 22d and ended over Hawaii on the 28th of December—taking six days in its passage over the islands, which is slower than the average time, as shown by the accompanying table of kona storms, 1914, to date.

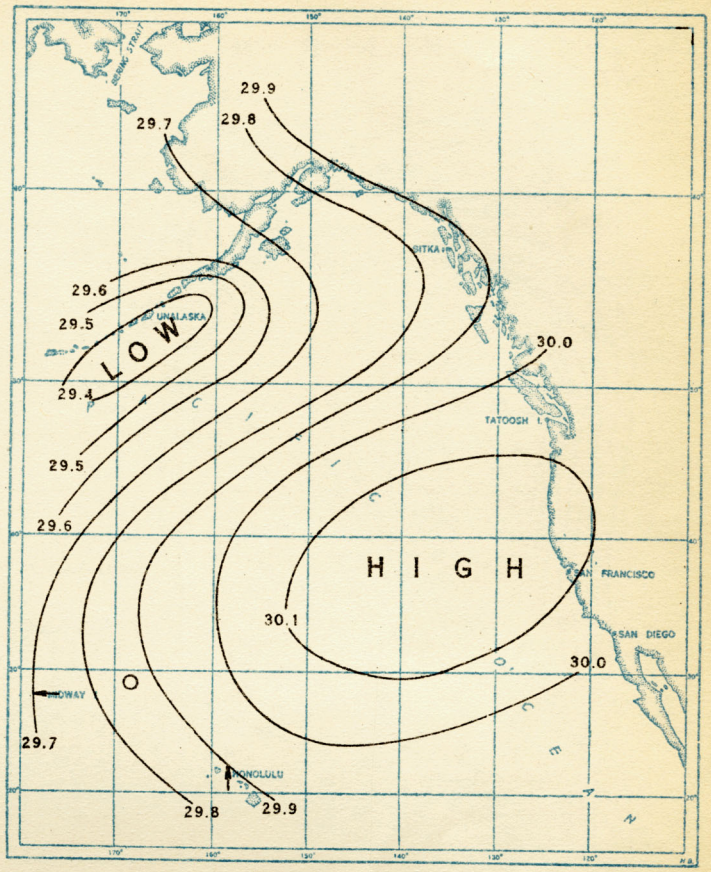
An examination of the weather maps of the North Pacific Ocean shows the apparent swinging southward* of the Aleutian Islands low area from December 20 to 24, and then its northward swing thereafter until reaching its normal position about the 28th.

Inspection of the accompanying table of kona storms will show that these southerly rainstorms, with few exceptions, reach Kauai, the northwesternmost of the main Hawaiian Islands, first, and Hawaii, the southeasternmost, last, in harmony with the southern or southeastern swing of the Aleutian Islands depression, at the season when it is most active, and when the north Pacific high-pressure area is least permanent and nearest the southern California coast. Occasionally, only a part of the islands of the group are affected by a kona storm, at which times only the northernmost. There have been exceptions to this rule, however, indicating that either the Aleutian Islands depression had spread southward to the east of Kauai, or there had been a development of a barometric depression somewhere to our northeastward in the oceanic area normally occupied by the north Pacific high-pressure area.

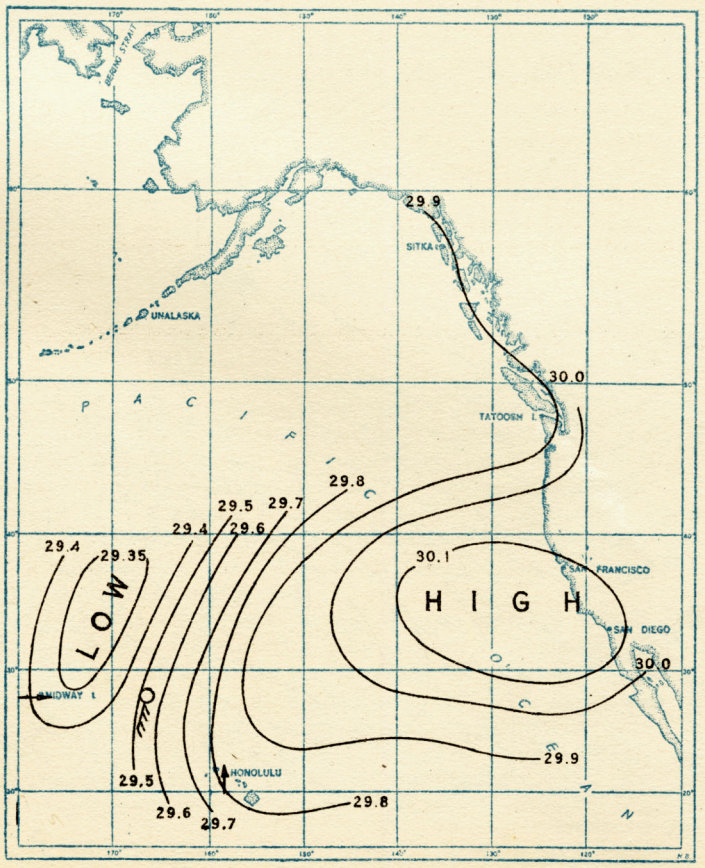
*It is preferred to think of Kona storms as independent developments, possibly as a result of the eastward movement of cyclonic systems in higher latitudes in which the center and the northern portion of the cyclone advance more rapidly than the southern and eventually merge with the semi-permanent Aleutian Low, rather than a bodily shifting of the latter to the southwest. Doubtless the configuration of the isobars in the Aleutian Low changes from day to day as cyclones advance from the west or issue toward the east-southeast. Such changes need not be considered as indicating a temporary shifting of the LOW itself.—EDITOR.



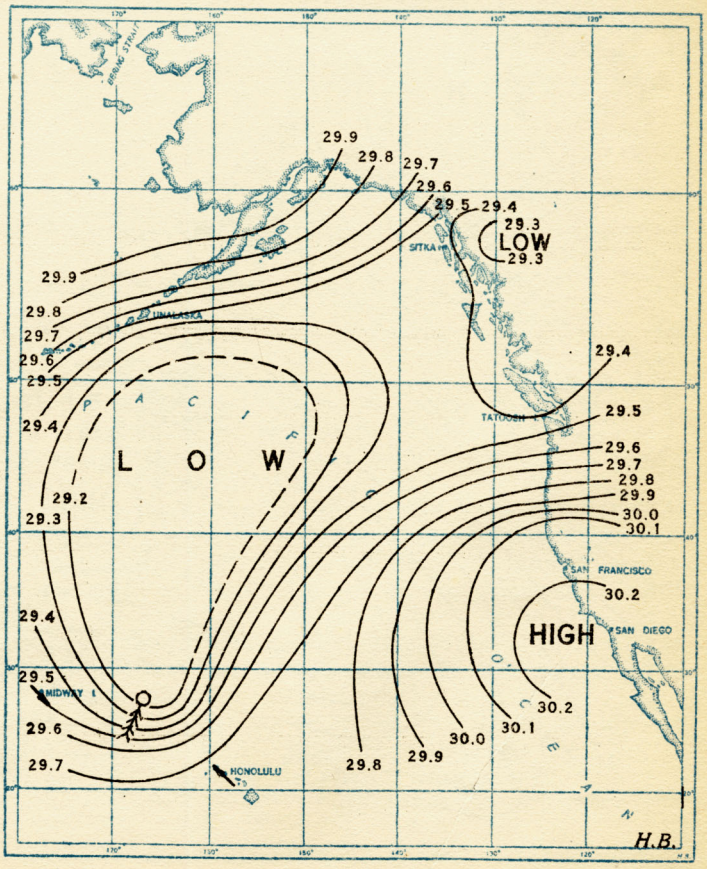
December 20, 1920



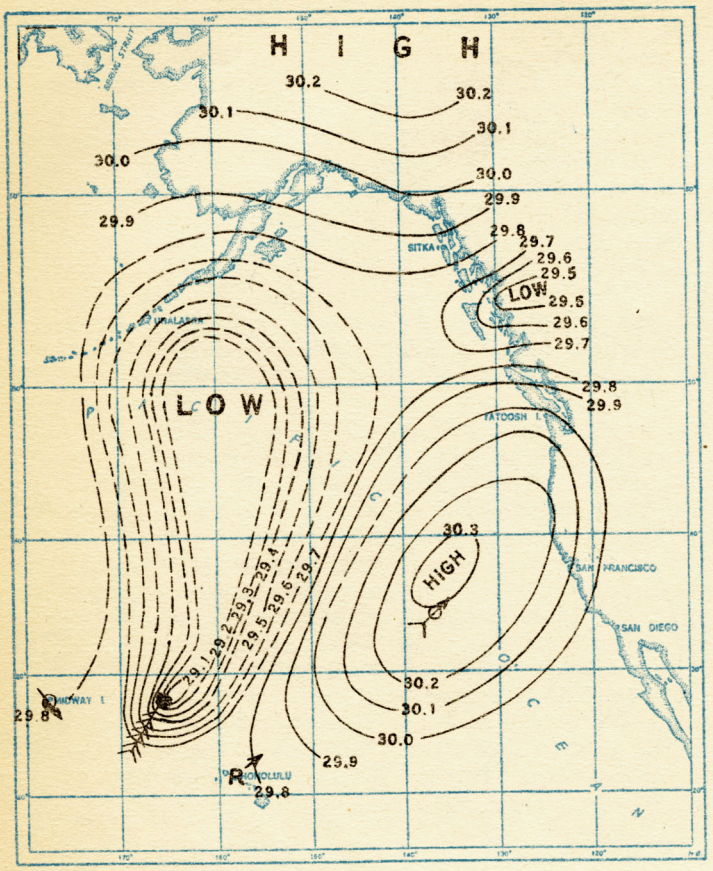
December 21, 1920



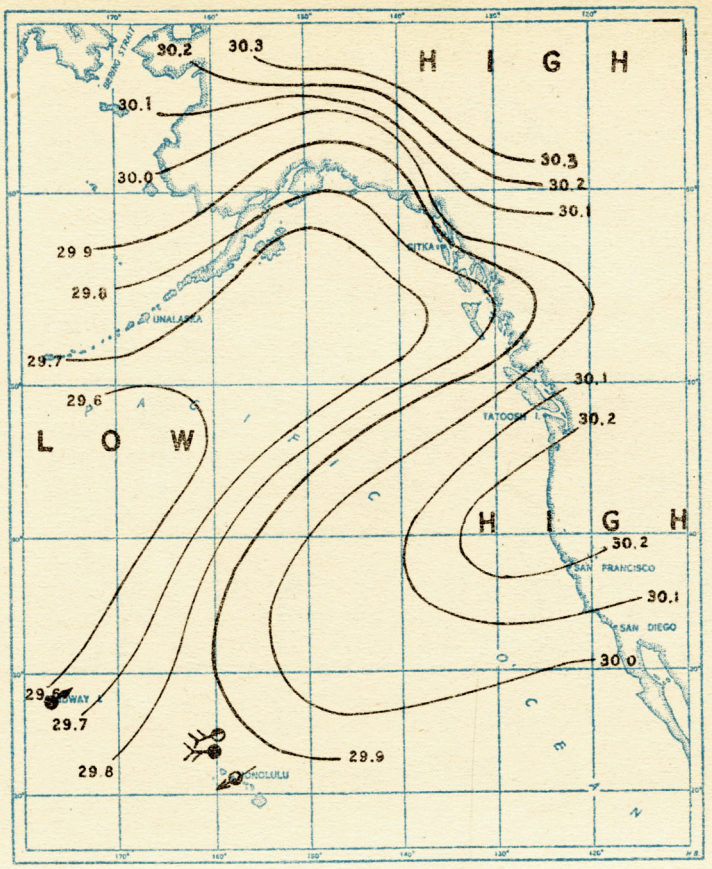
December 22, 1920



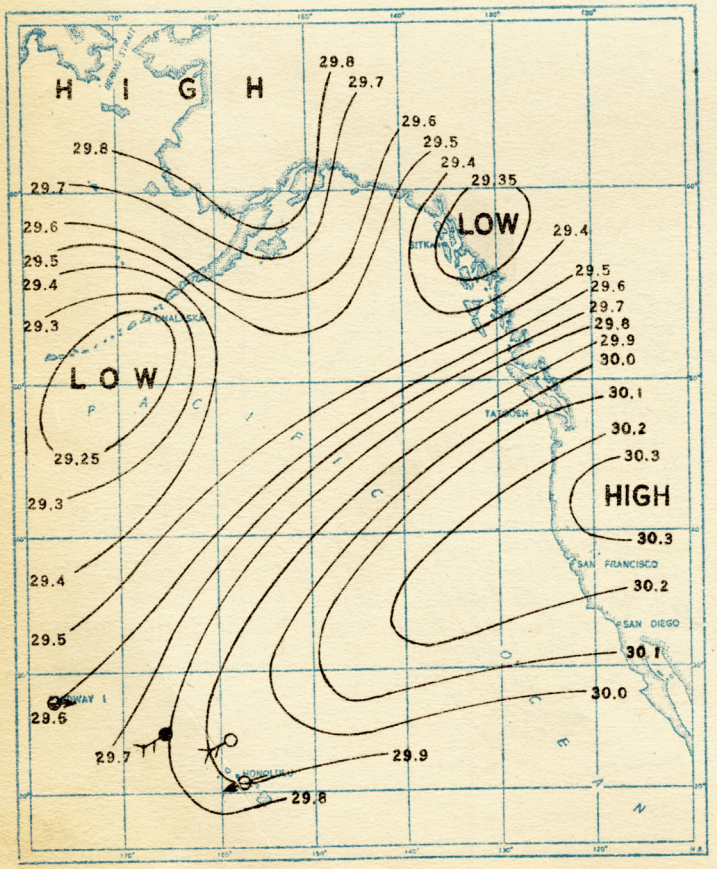
December 23, 1920



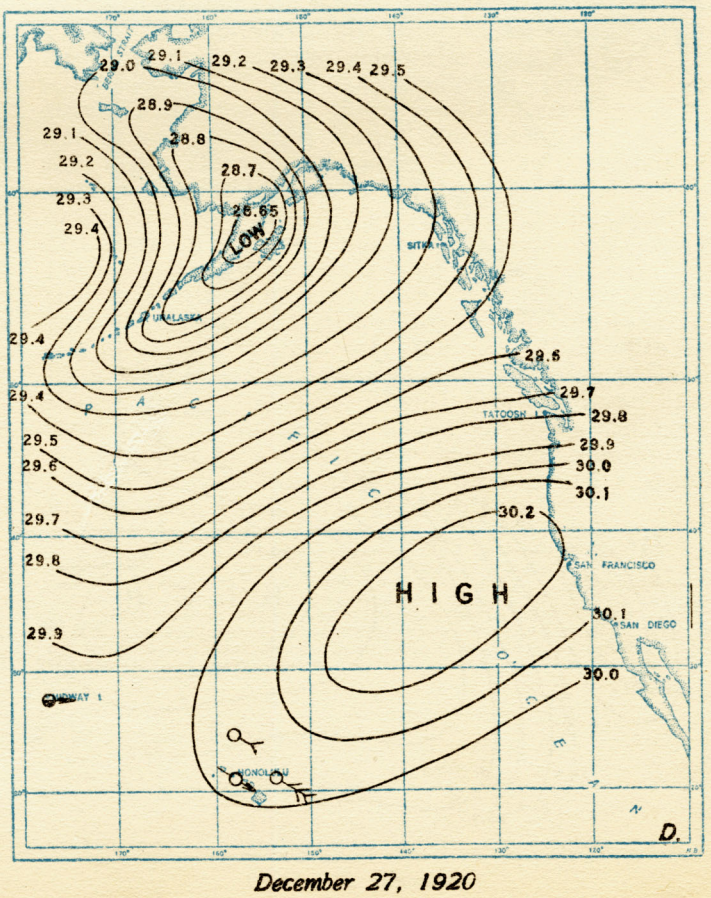
December 24, 1920



December 25, 1920



December 26, 1920



December 27, 1920

TABLE 1.—*Kona storms, March, 1914, to February, 1921, both inclusive.*

PRESSURE, WIND, AND PRECIPITATION DATA FOR HONOLULU.

Date.	Lowest pressure.	Wind. Maximum velocity.	Wind. Direction.	Wind. Prevailing direction.	Total rain.	Remarks.
1914.	*Inches.*	*Miles.*			*Inches.*	
Mar. 27	.....	14	SE.	SE.	0.09	Rain began Hawaii, 24th.
28	29.82	24	S.	S.	2.55	Rain ended Hawaii, Maui, Oahu, 29th.
Dec. 18	.....	22	SW.	SW.	0.00	Rain began Kauai, Oahu, 19th.
19	29.69	34	S.	SW.	1.53	Rain ended Hawaii, 22d.
1915.						
Nov. 11	29.82	21	S.	S.	1.04	Beginning and end of rain not clear; lowest pressure on 10th.
12	.....	10	NE.	S.	1.78	
Dec. 23	.....	8	S.	E.	0.00	
24	.....	27	SE.	SE.	0.40	Rain began Kauai.
25	.....	41	S.	SW.	2.82	
26	29.72	31	S.	SW.	0.33	
27	.....	34	SE.	SE.	1.37	Rain ended Kauai, Oahu, 29th.
1916.						
Jan. 16	.....	35	SE.	S.	0.00	Rain began Kauai.
17	29.64	49	SW.	S.	2.02	
18	.....	51	SW.	SW.	4.24	
19	.....	47	W.	SW.	0.78	Rain ended Hawaii, 21st.
Jan. 23	.....	16	SE.	SE.	0.00	Rain began Kauai.
24	29.86	18	SE.	SE.	0.00	
25	.....	32	S.	SE.	1.53	
26	.....	48	S.	NW.	0.94	Rain ended Hawaii, 28th.
Mar. 3	.....	19	SE.	SE.	0.01	Rain began Kauai, 1st.
4	29.68	28	W.	SE.	3.30	
6	.....	32	SW.	S.	0.58	Rain ended Hawaii, Maui, 8th.
1917.						
Jan. 9	.....	25	SW.	S.	0.59	Rain began Kauai.
10	29.80	30	SW.	SW.	2.07	Rain ended Hawaii, Maui, 12th.
Jan. 19	29.81	31	SE.	SE.	1.52	Rain began Kauai, 15th.
20	.....	29	SE.	SE.	0.90	Rain ended Kauai, 20th, Oahu, 21st.
Mar. 19	29.70	26	SW.	SE.	8.76	Lowest pressure, 18th.
20	.....	23	NE.	E.	4.78	Rain ended Kauai, 22d.
1918.						
Jan. 18	.....	32	SW.	SW.	1.21	Rain began all islands; ended 20th.
19	29.78	42	SW.	SW.	0.31	
Apr. 18	.....	17	S.	SE.	0.03	Rain began Kauai.
19	29.85	23	SE.	SE.	3.76	Rain ended Hawaii, 22d.
Nov. 24	.....	20	S.	SE.	0.70	Rain began Kauai.
25	29.75	39	S.	S.	3.63	
1919.						
Dec. 2	.....	19	S.	E.	T.	Rain began Kauai.
3	.....	37	S.	SE.	0.26	
4	29.74	20	SW.	W.	0.13	Rain ended Hawaii, 5th; Oahu, 6th.
1920.						
Jan. 9	.....	31	S.	S.	T.	Rain began Kauai.
10	.....	32	W.	W.	0.48	
12	.....	15	SW.	W.	T.	
13	.....	21	S.	S.	0.30	
14	.....	15	S.	SE.	T.	
15	.....	16	SW.	S.	0.00	
16	.....	18	S.	NE.	0.72	
17	29.58	25	NW.	NE.	2.08	Rain ended Hawaii, Maui, Oahu, 18th.

TABLE 1.—*Kona storms, March 1914, to February, 1921, both inclusive*—Continued.

PRESSURE, WIND, AND PRECIPATION DATA FOR HONOLULU—Contd.

Date.	Lowest pressure.	Wind. Maximum velocity.	Wind. Direction.	Wind. Prevailing direction.	Total rain.	Remarks.
1920.	*Inches.*	*Miles.*			*Inches.*	
Apr. 16	.....	16	S.	NE.	0.00	
17	29.94	16	S.	S.	0.01	Rain began Kauai.
18	.....	22	S.	S.	0.25	Rain ended Oahu, 23d; questionable weather touched Hawaii.
Dec. 22	.....	25	S.	SE.	0.11	Rain began Kauai.
23	.....	33	S.	SE.	4.57	
24	29.73	33	S.	S.	1.16	
25	.....	30	W.	W.	0.37	Rain ended Hawaii, 28th.
1921.						
Feb. 17	.....	33	W.	S.	0.12	Rain began Hawaii, 15th.
18	29.79	13	S.	S.	0.33	
19	.....	18	S.	S.	0.32	
20	.....	21	S.	S.	T.	
21	.....	31	W.	SW.	0.23	Rain ended Kauai.
22	.....	30	SW.	W.	0.03	Rain ended Oahu.

TABLE 2.—*Log of the schooner "Flaurence Ward," Midway Island to Honolulu, Dec. 21–25, 1920 (157° 30′ meridian time).*

Date.	Time.	Position. N. lat.	Position. W. long.	Barometer.[1]	Attached thermometer.	Wind. Direction.	Wind. Force.	Remarks.
		° ′	° ′	*Inches.*	°F.			
Dec. 21	1:30 a. m.	28 48	168 29	29.90	68	Calm.	0	Rolling sea.
22	1:30 a. m.	27 40	167 30	29.75	69	ENE.	5	
	4 p. m.	.....	.....	29.60	....	SE.	4	Lightning.
	6:30 p. m.	.....	.....	29.53	....	S.	4	
	8 p. m.	.....	.....	29.50	....	SSW.	5	Terrific lightning.
	12 midnight.	.....	.....	29.40	....	SSW.	....	Heavy rain.
23	1:30 a. m.	27 42	166 23	29.30	69	SSW.	8	Rough sea.
	4 a. m.	.....	.....	29.30	....	SSW.	....	Squally and lightning.
	8 a. m.	.....	.....	29.30	....	SSW.	8	Squally.
	Noon.	.....	.....	29.28	....	SSW.	8	Do.
	4 p. m.	.....	.....	29.20	....	SSW.	9	Do.
	12 midnight.	27 40	166 15	29.10	69	SSW.	10	Do.
24	1:30 a. m.	.....	.....	29.10	69	SSW.	10	Do.
	4 a. m.	.....	.....	29.10	....	SSW.	10	Do.
	8 a. m.	.....	.....	29.20	....	SSW.	11	Do.
	Noon.	.....	.....	29.26	....	SSW.	11	Do.
	4 p. m.	.....	.....	29.32	....	SW.	10	
	8 p. m.	.....	.....	29.40	....	SW.	8	
	12 midnight.	.....	.....	29.50	....	SW.	6	
25	1:30 a. m.	26 27	161 58	29.52	69	SW.	9	Rough sea; barometer rose slowly as wind died down; wind did not shift in squalls; finished in direction in which it started, ENE.

[1] Aneroid barometer compared at station upon return to Honolulu and found correct.

GENERAL SURVEY OF METEOROLOGICAL PROBLEMS OF PAN-PACIFIC COUNTRIES.[1]

551.55 (265)

By LAWRENCE H. DAINGERFIELD, Meteorologist.

[Weather Bureau, Honolulu, Hawaii, Oct. 28, 1920.]

The Pacific Ocean embraces an area of about 55,000,000 square miles, equivalent to the entire land surface of the globe, and presents to the meteorologist, partly by reason of this vast extent, many features of great interest and importance. In regard to some of these we are already more or less well informed, but of others our knowledge is very meager and many important questions concerning them remain to be answered.

The coordinated efforts of the several nations whose lands lie within or about the far-reaching borders of the Pacific are essential to the proper study of these features and to success in any attempts that may be made to solve the physical problems associated therewith.

What appear to be the chief features of Pacific Ocean meteorology calling for study at the present time are presented briefly below, the object being to establish a basis for systematic investigation in the future. It is recognized, of course, that any plan made now, must necessarily be subject to modification.

The survey may be presented in the form of a series of questions:

1. What is the normal distribution of atmospheric pressure over the Pacific Ocean and its adjacent land areas?

2. What is the normal *seasonal* distribution of pressure?

3. What regions are under permanent high pressure? What under permanent low pressure?

4. What are the regions occupied by high or by low-pressure areas, in which pressure conditions vary, or indeed are reversed, with the change of season?

[1] Reprinted from *Proceedings of the First Pan-Pacific Scientific Congress.*